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ABSTRACT

This survey covers the literature relating to automatic indexing techniques, services, and applications published during 1969-1973. Works are summarized and described in the areas of: (1) general papers on automatic indexing; (2) KWIC indexes; (3) KWIC variants listed alphabetically by acronym with descriptions; (4) other KWIC variants arranged by subject fields; (5) automatic indexing of numerical data; (6) miscellaneous techniques; (7) chemical notations; (8) thesaurus construction and related researches; (9) general reviews listed chronologically; and (10) economic aspects. A complete list of the 393 references is attached. (KP)

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A STATE-OF-THE-ART SURVEY

ON

A U T O M A T I C I N D E X I N G

by

Felix Liebesny

B.Sc.,F.I.Inf.Sc., F.I.L., A.L.A.

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FOREWORD

The considerable growth of interest in, and use of, automatic indexing techniques has engendered a corresponding increase in the literature relating to this topic. Lately it has been felt that since the last major survey by M.E. Stevens (National Bureau of Standards Monograph 91, February 1970) so much has been published as to warrant a further state-of-the-art report. This edition has been prepared on behalf of the International Federation for Documentation (FID) through Unesco Contract 280 103 and surveys the literature from September 1969 to December 1973.

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ABSTRACT: This survey covers the literature published during the period 1969-1973 and analyses various KWIC services and techniques and their applications as well as automatic indexing of numerical data. Documents on the construction of thesauri and on systems of chemical notation are also reviewed. 395 references.

1. INTRODUCTION

1.1. Scop

This survey has been compiled on behalf of the International Federation for Documentation (FID) through Unesco Contract 280 103 and surveys the literature relating to automatic indexing techniques, services and applications as described in publications issued during the period from September 1969 to December 1973. The start of this period follows immediately on the last publications mentioned in the 2nd edition (355) of this report produced by M.E. Stevens which was published in February 1970. (The first edition covered the period up to mid-1964.)

Although numerous publications have been collected during the compilation of the present edition it was found that a considerable number were survey articles without any substantial novel contributions; it has therefore been decided to list those separately in Section 8 and also to provide an alphabetical list of some acronyms whose number has increased perhaps even more than the amount of literature itself (Section 3.3.1.)

1.2. Definition

While the origin and early development of automatic indexing have been adequately described in the introduction to the 1st edition of this report it may be useful to repeat here the definition of the concept of "Automatic indexing" so as to exclude some other aspects of informatics.

Thus this report is concerned with the use of machines to extract or assign index terms without human intervention once programs or procedural rules have been established; in this context the term "Indexing" relates to two interconnected functions:

(1) choosing clues that will serve to identify, for purposes of later retrieval, a particular book document or other recorded item, and
(2) either marking on the item itself or recording as a separate item-surrogate the tags, labels, or codes representing these clues.

1.3. Methodology and acknowledgements

In the compilation of this state-of-the-art survey a large quantity of references to apparently relevant literature was found through systematic scanning of secondary publications, especially "Library and Information Science Abstracts", "Computer Abstracts" and "Referativnyi Zhurnal: Informatika". A recent analysis by L.H. Campey (83) on "Generating and printing indexes by computer" was also used extensively and the author would like to express his gratitude to the valuable assistance derived from that work. The author would also wish to record his appreciation for the untiring help provided by Mrs Dera Bodo, M.A., during the collection of references.

Although systematic searching through the literature yielded many references it was felt that a comprehensive listing would be so large as to be unhelpful and it was therefore decided to apply certain criteria of selectivity. As a result this survey is not complete in that it does not contain all the works written about this subject. It does however aim at presenting a representative list of the major contributions to and reviews of this subject.

1.4. Arrangement

As in the previous editions of this report the references are grouped under broad headings and discussed briefly while the greater part of the work is devoted to an alphabetical listing of the cited references.

2. GENERAL

In this section are included papers on the development of automatic indexing without specific reference to a technique or system, but which have wider applicability. It should be noted that items which merely review the field are included in Section 8.

Major contributions were found in the books by Bely et al. (43) and Sparck Jones (350).

Since automatic indexing and classification are closely related subjects it is not surprising that the attention of the classification experts has been drawn to this topic. Thus A.C. Foskett (146) discussed the subject approach and his brother D.J. Foskett (147,149) the special requirements of indexing for the social sciences and also the work done by the Classification Research Group (148).

Another area of wide interest, yet with a specific relationship to automatic indexing, is the field of patent literature where the moves towards a more centralized searching strategy - accentuated perhaps by the preparations for a European patent system - have inevitably concentrated thoughts on the applicability of auotmatic indexing techniques in order to reduce the gigantic task of indexing the world's output of some 500 000 patents per annum. Some pilot work done at the IIB (International Patent Institute) at The Hague is described by Putz (305) while the work done on U.S. patents is considered by Gerson (160) and the studies in Moscow on compiling a keyword index to the IPC (International Patent Classification) are dealt with by Kravets et al. (239). A more limited approach by Stibic (356) concerns a subset of 200 patents on television technology whose text of nearly half a million words was read and indexed automatically for subsequent analysis.

The general limitations were discussed from the theoretical point by Abe et al. (2) who dealt with the syntactic and semantic characteristics of titles of scientific papers. A similar approach was initiated by Higgins et al. (187) whose project at Belfast University was concerned with a large collection held on random access storage devices. Graves's feasibility study (172) dealt with very similar aspects of the problem as does O'Toole (284) with his work at the U.S. National Bureau of Standards, e.g. CAIC, IBSAT and TESAT, and Bottle (65,67) with specific reference to the titles of chemical documents.

The role of automatic indexing in the discipline of information was discussed from the theoretical and philosophical point by Dietze (114) while a more practical approach was adopted by Korobkov et al. (237, 238) who discussed the role of computers in the preparation and publication of current awareness services.

Finally the problem of indexing complete texts was dealt with by Otradinskii (285), and Borko (61) and Hines et al. (189) discussed the indexing of books.

3. KWIC INDEXES

The KWIC technique of indexing by Keyword in context is too well known to warrant further description here and its widespread use is illustrated by numerous descriptions of the most diverse applications. This Section will therefore be concerned with 3.1. KWIC developments 3.2. KWIC applications, and 3.3. KWIC variants arranged in alphabetical order of acronym describing the technique or installation, with cross-references where applicable.

3.1. KWIC developments

In the KWIC techniques per se comparatively few developments have taken place and most of the contributions which have been found dealt with specific applications in certain subject areas or for certain types of document.

The more general treatises of the KWIC process were concerned with the need for broader guidelines and criteria as expressed by Taneja et al. (360) and also by Lodder (252, 253). A critical look at KWIC was taken by Humbert (199) while Foskett (150) was brave enough to describe the failures of some KWIC experiments. The importance of avoiding or correcting mistakes in KWIC indexes - such as inconsistencies of spelling, errors, hyphenation etc. - was stressed by Fenichel (139). A survey of KWIC index generating programs was prepared by Campey (81).

The foreign language problem was the subject of a contribution by Ohgai (283) who described a method of combining the Japanese Kana script with alphanumeric script in the preparation of a KWIC index; another solution to the same problem was offered by Uemura (370). Czech linguistic problems were highlighted by Ecler (126) and Hungarian ones by Szentgyorgyi (359).

The developing countries appeared to have special problems requiring individual treatment as shown by Padilla (286) and Gravenhorst (171) for some case studies from the Argentine, Hubert et al. for Morocco (198) and Ronchetti Teixeira for Brazil (311).

3.2. KWIC applications

The specialized subject areas covered by articles included economics (Fabian 130), nuclear information (Günther et al (175) on Cern and Haeuslein et al. (177) on Oak Ridge National Laboratory, library literature (Brodie 71), psychology (Bottle 66), social sciences (Scherer-Goossens 325), and transportation and planning (Garbea (157), Thomas (366,367)).

The special types of document which were considered comprised drawings (Spitznas 353), the proceedings of a public enquiry held in connexion with transportation and planning (Thomas 367), book titles (Bonney 60), and statistical publications (Dienes et al. 113).

More sophisticated forms of KWIC are the double-KWIC (see under 3.3) and a three-level KWIC index with permanent pre-coordination (Aries 9). Various minor modifications and refinements introduced at Imperical Chemical Industries' KWIC system were described by Matthews et al. (263).

The selection of keywords demanded closer study and experiments dealing with their direct selection were reported by Helbich (183), their frequency distribution by Gor'kova (165) and a lexico-grammatical analysis by Kuznetsova (240). The retrieval effectiveness was examined by Yerkey (391).

3.3. KWIC variants

These are listed below in alphabetical order of acronym of either the technique or the system in which it is used. Cross-references or multiple entries have been made where applicable.

3.3.1

AIM-TWX (Abridged Index Medicus) is a variant of MEDLARS (Blase et al. 54, Moll 274)

AKWIC (Author and keyword in context) is a compromise between KWIC and WADEX (q.v.) described by Juhasz (211)

ALLIANCE is a system for processing indexes for the periodicals "Céramique" and "Verres et Réfractaires" (Brisner 70)

ASI (Articulated subject index) is a generic term used inter alia by Hall (178) in describing a computer-generated index technique, and by Lynch et al. (261) for a programming suite

ASTI is a Czech system for a computer information system described by Fendrych (136, 137, 138) and Fogl et al. (144)

BROWSER is an automatic text retrieval system employing an automatic indexing system by creating an inverted file (Williams 385, 386, 387)

CAIC (Computer-assisted indexing and categorising) is a U.S. National Bureau of Standards program (O'Toole 284)

CAIN (Cataloguing and indexing is a system introduced at the US National Agricultural Library which utilizes enriched titles (Lebowitz et al. 249, van Dyke et al. 372)

CAPRI (Comouter-aided personal reference index) is described by Cook et al. (99) for use by individual research workers and groups at the U.K. Atomic Weapons Research Establishment

CHERCHE is a system similar to CAPRI and was described by Cedergren (87)

COIN (Cobol indexing and maintenance system) was developed by the National Computing Centre Ltd. for the building industry (282)

DOUBLE-KWIC provides an increased number of subordinate entries by rotating the remaining terms round each keyword. Its main application up to now has been for chemical line notation (Petrarca et al. 292, 293; Lay et al. 246, 247) A general description was presented by Willey (384). (See also KWOC)

EKO-INDEX is a Czech indexing service for economic information using a permuted term index (Kimlička 227, 228, 229)

FAMULUS is a system designed for small collections of up to 10 000 documents to augment personal documentation efforts and was developed by Burton et al. (77). An application for papers on the culture of freshwater invertebrates was described by Campbell (80)

GENDEX (General indexer) is a concordance generator used in indexing (Smith 346)

GREMAS (Generic retrieval by magnetic tape storage) was developed by Farbwerke Hoechst A.G. for coding low-molecular weight compounds Mitsuo et al. 271; Rössler 314)

IBSAT (Indexing by statistical analysis tables) is a U.S. National Bureau of Standards program (O'Toole 284)

IFIS (International Food Information Service) utilizes a modified KWOC system (Mann 262; Schützsack 331)

INDACS (Indexing by the Atlas computer system) is a KWIC/KWOC system developed by London University Computing Services Ltd. (225); see also Thomas et al. (365)

INDEX is an application program of a KWIC-type keyword listing, mainly for personal bibliographies (Bridges 68)

INDORES 4 is a Czech information system employing inter alia automatic indexing for the field of information science (Merta 266) and history (Pickova 295)

INIS (International Nuclear Information System) is centered on the IAEA (International Atomic Energy Agency) in Vienna which utilizes a special thesaurus with 12 000 descriptors and 4000 forbidden terms. The construction of the thesaurus is described by Brzicky (73) and Poletylo (298, 299), its correction routines by Hino (193) and the methods of indexing by Bielicka (51, 52) which are also outlined in the IAEA manual (202). A general description of the system was published by Murty (280) and its working was reviewed after 20 months operation by Hybner (200) and after 3 years by Hermannson-Snickers (186). The efficiency of the system is dependent on the contributions from national members, e.g. India, as described briefly by Kamath et al. (214)

IRMS (Information retrieval and management system) is an in-house development of a package for the indexing of chemical structures and laboratory experiments (Abbott et al. 1)

KLIC (Keyword lists in context) is a technique more concerned with keywords taken from the text than the title and has been studied at the Illinois Institute of Technology (Williams 388)

KOMPAS is a Soviet information retrieval system described by Agraev et al. (4, 5, 6) and Borodin et al. (64) who has also studied the question of word lists (63) and co-occurrence graphs (62) in the construction of indexes

KWAC (Keywords and context) is a KWIC-type indexing system developed by Unilever Computer Services Ltd. which utilizes significant keywords in the text as a basis for keyword selection in the generation of KWOC entries (Lester 251)

KWIC-KWOC (Keyword in context - Keyword out of context) mixtures have been tested by Thomas et al. (365) with manual selection, Porter (302), Jackson (207), Blum (57) and Asleson (17) for finding dissertations. A KWIC index enriched and tagged by KWOC with special user orientation was developed by Flury et al. (143)

KWOC (Keyword out of context) was developed out of KWIC so that the keyword is displayed in a more prominent form than in KWIC. Among the more important uses of this system are applications to the retrieval of state and local documents (Schwartz 332), information activities (Choroszuszyna 92; Elgad 128), research activities (Keren et al. 224), newspapers (Davis et al. 107) and the literature on food sciences (Mann 262) and on aeronautics (Barnett 37, 38).
Comparisons of KWOC with other types of index were conducted by Auld (20) and Toma (368).
More general papers on KWOC were presented at a conference (235) and by Pawlowics (291) and Sokolowska et al. (349) on the research work carried out at CIINTE (the Polish Central Institute for Scientific, Technical and Economic Information).
The influence of the grammatical form on the information value of KWOC terms was studied by Choroszuszyna (93)

LIDOK (Literatur-Dokumentation) is a program developed at the Aachen Higher Technical School Machine Tool Construction Laboratory for the indexing or searching of documents (Domke et al. 120)

MAI (Machine-aided indexing) was developed at the U.S. Defense Documentation Center for indexing report literature (Klingbiel 231, 232)

MALIMET (Master list of medical indexing terms) permits indexing in depth for the Excerpta Medica service of up to 250 000 documents per annum (Urata 371; Collison 98)

MEDICO (Model experiments in drug indexing by computer) was developed at Rutgers State University by Artandi (12, 13, 14, 15, 16); see also Collison (98)

MEDLARS (Medical literature analysis and retrieval system) has been developed in several countries to provide on-line indexing facilities. Tests have been carried out at Newcastle University (Barraclough et al. 41) and by Adams (3) who compared it with other systems

MeSH (Medical subject headings) was developed in conjunction with the MEDLARS tests (Mench 279; Moll 274)

MINERVE (Mécanization de l'information dans l'exploitation et la recherche verrières) produces indexes for a bulletin and a periodical in the glass industry (Robredo 310)

MISA (Mechanized indexing system by Anzai) is a system for indexing periodical articles by KWIC and KWOC methods (Anzai 8)

MULTITERM is a technique devised by Skolnik (340, 342) and used inter alia for the production of a multilingual index

PASCAL (Programme appliqué à la sélection et à la compilation automatique de la littérature) was introduced by the Centre de Documentation of the French Centre National de Recherche Scientifique and generates subject indexes with the keywords written on the worksheets of the abstracts being prepared for the Bulletin Signalétique (Buffet 74; d'Olier 117, 118, 119; Dusoulier et al. 122)

PERMUTERM is an index published by the Institute for Scientific Information (Philadelphia, Pa.) and permutes all significant words in a title to generate the maximum possible pairs of terms; it is used in the preparation of various citation indexes (Garfield 158; Institute for Scientific Information 203, 204)

PRECIS (Preserved context index system) is a development within the British National Bibliography's work on MARC (machine readable catalogue) which produces a printed alphabetical subject index with multiple entries (Austin 21, 22, 23, 24, 25; Gold 164; Kemp 221, Metcalfe 268; Palmer 287; Robinson 309; Hassell 181). The generation program was described by Campey (81)

PRIMAS (Programmpaket zum Rückgewinn und Indexieren mit Maschinenhilfe) is a semi-automatic indexing system which provides computerized techniques for direct use by human indexers and analysts; it has been developed for eventual use at the European Patent Office at Munich (Axhausen et al. 30)

RILM (Répertoire international de la littérature musicale) is a system developed by Brook (72)

SABIR (Système automatique de bibliographie d'information et de recherche en carcinologie) is a cancer information system using coordinate indexing (Wolff-Terroine 389)

SLIC (Selected listing in combination) is an established method whose mathematical basis was investigated by Rush et al. (317)

SLIP is an integrated machine-manual system which has been adapted to produce indexes to "Rock Mechanics Abstracts" (Wentzel et al. 380)

SMART is a retrieval system based on syntactic rules which has been developed by Salton (320, 321, 322, 323) (now at Cornell University, U.S.A.). The techniques based on this system have been used by Sparck Jones (350) to develop an automatic keyword classification system and by the originator for comparing with MEDLARS (319). Keen (219) has also used SMART in his comparative tests

SPIRAL (Sandia's program for information retrieval and listing) is a system which produces inter alia a multi-level index from a vocabulary file (West 383)

SPLEEN is a code used in the production of six indexes to a monthly classified bulletin (Cadoux 78)

STAIRS (Storage and information retrieval system) was designed by IBM and incorporates the machine indexing feature in a full-text system Hermann 184, 185)

SYDOLAB (Systeme de documentation de laboratoire) utilizes a keyword system based on PL/1 index generation program for the handling of nuclear information (Gervais 161)

TESAT (Teaching sample tables) is a U.S. National Bureau of Standards program (O'Toole 284)

WADEX (Word and author index) is the index to "Applied Mechanics Review" of the KWOC type and was used in a comparative study by Anzai (8).

3.3.2. Other variants

In this Section a list is provided of other variants of KWIC arranged by subject fields - except for chemical notation which is discussed separately in Section 6) - in which such systems are employed.

Archival business documents:	Agraev (5)
Biopsy findings:	Gell (159)
Cartography:	mapping information is computer indexed at the U.S.S.R. Institute of Geodesy, Aerophotography and Cartography (Sukhov et al. 357)
Civil engineering:	system used at Melyepterv (Hungary) (Czuni 103)

Concordances:	Bibershtein (50); a program for indexing concordances was devised by Hines et al. (192)
Current awareness services:	work at VINITI (Petrov 294, Potapovskii et al. 303)
Dictionary compilation:	the use of an automatic concordance program for compiling a concordance dictionary was described by Bibershtein (50) while biographical dictionaries were the subject of a study by Damerau (104); a multilingual index was produced via a Multiterm program by Skolnik (340)
Dissertations:	index to "Dissertation Abstracts International" (Scott 334; Asleson 17)
Electrical engineering:	Shneerson (336)
High-energy physics:	the Euratom index (Lustig 259; Toma 369)
Law:	studies at the American Bar Association (Dennis 109)
Management:	the ANBAR service (Bakewell 33, 34)
Medicine:	a review of the various indexing services by Wersig (382)
Metallurgy:	a description of the U.S. National Bureau of Standards' alloy data centre index (Carter et al. 80), of the International Nickel Co.'s Anglo-American cooperation (Kelly et al. 220), and of the Wendel Sidelor steel company (Berger 46)
Mining:	index to a bibliography produced at the Safety in Mining Research Establishment (Belton 42)
Monographs:	an in-depth indexing method by Egeland (127)
Nitrogen industry:	Frants et al. (152, 153)
Oil:	the U.S.S.R. Neft scheme is capable of mass indexing documents with a machine descriptor dictionary (Gorokhov et al. 166, 167, 168; Mekhtiev (265)
Patents:	Blumstengel (58), Girshberg et al. (163); Kawasima (218)
Slides:	the photographic slide collection at the Santa Cruz University of California was automatically indexed with automated cross-indexing (Simons et al. 337; Tansey 361)
Textiles:	experimental work at the Shirley Institute (U.K.) for indexing "World Textile Abstracts" with the MIT (Massachusetts Institute of Technology) thesaurus of textile terms (Cu...

birch et al. 102; Institute of Textile Technology 205)

University libraries: compilation of a computer-printed subject index at James Cook University (Smollen et al. 348)

Visual arts: index to a visual arts collection (Davis 108)

Viticulture: Russian work on automatic indexing of English-language texts on wine making etc. (Tarasova 362).

4. AUTOMATIC INDEXING OF NUMERICAL DATA

The references found in this survey on the indexing of numerical data related almost exclusively to the processing of UDC (Universal Decimal Classification) numbers as a meta-language in indexing procedures.

4.1. Universal Decimal Classification

The applications of computerization ranged from the comparatively simple process of producing inverted indexes for large technical libraries in Canada (library of the Boreal Institute for Northern Studies at the University of Alberta, Benbow 44 and Heaps et al. 182) and Denmark (Tekniska Bibliotek, Copenhagen, Barnholdt 39, 40) and in a large public library in France (Beyssac 49) to dealing with specialized collections concerned with the automotive industry in the U.S.SR. (Zhzhka 393) using a modified KWIC method, and hydrometallurgy (Popov 301).

A survey of the present situation of mechanization of the U.D.C. was made by Rigby (306) who also looked at the future prospects, at least as far as 1985 (307). Another assessment of the applicability of mechanized U.D.C. was made by Fukai (156) who advocated a two-stage method using U.D.C. via a natural language similar to the method employed by the American Institute of Physics.

General papers on this topic were provided by Koch (234) who showed also together with Schneider (326) that KWIC-modified KWOC approach would render U.D.C. suitable for machine processing; by Scibor (333) who discussed Poland's plans in this discipline; by Thannabauer (364); by van Halm (373), and by Zajac (392) who described the IGA program for the automatic grouping of information.

4.2. Others

Ivankin (206) described the automatic indexing of dimensions of automotive parts by developing a conceptual design of an algorithm. Rukman (316) described a similar method

5. MISCELLANEOUS TECHNIQUES

In this study several references were found which did not fit easily into the divisions employed. The diverse techniques described in those references are here grouped together as far as possible so as to facilitate use of this Section.

The close link with problems of language and machine translation is shown by studies of descriptor dictionaries used in the indexing of patents (Girshberg et al. 163), the production of a multilingual index by the Multiterm system (Skolnik 340), and the application of a transformational model grammar to automatic indexing (Fishmann 142).

Permuted indexes were reconsidered by Hines et al. (190) and by Jung (212) for use with the Robotron 300 computer while Schneiderman (327) introduced a refinment of permuted title indexes by using a lexicographically edited list of descriptors.

New techniques were also suggested by Klingbiel (253), Long et al. (256) for a truncated search title index, Pushkarskaya (304) by using non-descriptor languages, and Falkov et al. (131) who used contextual relations similar to those employed in machine translation.

Finally, some comparative tests of systems were carried out by Elvesjö et al. (129) and by Frants et al. (151).

6. CHEMICAL NOTATIONS

In view of the various systems of nomenclature relating to chemical compounds and their structure the printed literature frequently employs formulae and/or diagrams such as rings for steroid or hydrocarbon radicals etc. Such geometrical representations are not however very concenient input material for information processing machines. Therefore various methods of denoting chemicals have been devised.

6.1. Among the papers on classical methods Maxwell (264) reviewed the notational scheme developed by G.M. Dyson.

6.2. A review of the techniques used for information storage and retrieval in chemistry was produced by Seki (335).

6.3. Applications of more recent methods include:

6.3.1. Double-KWIC (see Section 3.3.1.) has been used for chemical line notation (Petrarca et al. 292, 293; Lay et al. 246,247; Willey 384)

6.3.2. The GREMAS (Generic retrieval by magentic tape storage) system was developed by Farbwerke Hoechst A.G. and forms an integral part of the IDC (Internationale Dokumentationsgesellschaft für Chemie) automated information retrieval system, centered on Frankfurt/Main (Mitsuo et al. 271; Rössler et al. 314).

6.3.3. The IUPAC (International Union of Pure and Applied Chemistry) was adapted for computer use by Polton (300).

6.3.4. The MCC topological screen system has been devised for polycyclic compounds (Hosoya 196) and especially for pesticides (Morneweck et al. 275). A search procedure through the Chemical Abstracts registry was described by Milne et al. (269).

6.3.5. A variant of MULTITERM (see Section 3.3.1.) has been adapted by Skolnik (339) for a chemical fragment notation index, used inter alia for literature on chemical propellants (341, 344).

6.3.6. The most widely used system is however the WLN (Wisswesser line notation) whose application to biological activity files was described by Bond et al. (59). Its computer generation and the generation of its substructure codes were discussed by Farrell et al. (132), Granito et al. (170) and Koniver et al. (236). Other papers on WLN were contributed by Feldmann (134, 135), Maxwell (264) and Palmer (288).

6.3.7. Other codes include a linear code developed by Ignatova et al. (201) and a chemical substructure index by Granito et al. (169). The random block coding system developed by VINITI was described by Mishenko et al. (270). Further contributions were made by Feldmann et al. (133), Legatt et al. (250) Loening et al. (254), Plotkin (297) and Rowlett et al. (315).

6.4. The problem of vocabulary control was treated by Davis (106), and Campey et al. (84) discussed the question of interconversion of chemical structure systems.

7. THESAURUS CONSTRUCTION AND RELATED RESEARCHES

The selection of indexing terms by random techniques, use of systematic thesauri and other methods is an important adjunct to automatic indexing although such work may well have wider applications than automatic indexing. In this area it has certainly been noticeable that the use of natural language is becoming more prevalent.

7.1. General

Much thought has been given to this topic by research workers in the field of linguistics such as Sparck Jones with her two books on "Linguistics and information science" (352a) and "Automatic keyword classification and information retrieval" (350). Similarly, Salton in his "Automatic information organization and retrieval" (321a) devoted a considerable portion of his compilation to this subject. Mølgaard-Hansen wrote a synopsis on the compatibility and complementarity between indexing languages (273); this aspect was also treated by Avramescu (27), Chavdarov (28), Burgess (76) who stressed the limitations, and Vlasak (375). Janos (208) discussed the basic problems of automatic indexing theory, and Cresson et al. (100) of its applications.

7.2. Thesaurus construction

The history of thesauri and their construction was described in a fascinating paper by Sparck Jones (351) with many examples and a good bibliography. The theoretical foundation of thesaurus construction was surveyed by Kim (226). The whole complex problem of controlling the construction of a thesaurus was discussed by Lancaster in his book "Vocabulary control for information retrieval" (242) in which both aspects of thesaurus construction were dealt with, viz. manual and machine methods. Several other papers were concerned with both aspects, e.g. Lüpnitz (258), Kerchovec (223) and Hoppe (195). Werder (381) and Hines et al. (188) concentrated on the task of maintaining (i.e. updating) thesauri while the economic aspects were discussed by Hammond (179). A flowchart for indexing with a thesaurus was prepared by Wellisch (378).

Some problems in the selection of keywords were cited by Helbich (183) and Sokolowska et al. (349) who wrote about her experience in the preparation of a KWOC index to "Przeglad Pismiznictwa Zagadnien Informacji". Various methods of compression were used by Gilchrist et al. (162), Louis-Gavet (257) and Schreiber (328).

7.2.1. Statistical methods

Statistical analyses of word frequencies and the like are among the best represented techniques employed in the construction of thesauri. General surveys of such methods were made by Gor'kova (165) and Vasak (374) and by Wolff-Terroine et al. (390) with special reference to a medical thesaurus. Rosenberg used statistical measures to predict terms (312, 313). Other contributions were made by Svenonius (359), Moskovich (277), Avramescu (26, 28, 29) and Augustson et al. (19) who made use of graph theoretical clusters to derive term relations. Sparck Jones (352) and Salton et al. (324) con-

centrated on term specificity. A method for estimating relevant descriptors was described by Schreiber (329) and a program (IBSAT = index by statistical analysis tables) was developed at the U.S National Bureau of Standards by O'Toole (284).

7.3. Special thesauri

Since the problems of thesaurus construction may vary somewhat in different disciplines the literature of special thesauri has been separated here and is arranged below by subject in alphabetical order:

Aeronautics:	the NASA (U.S. National Aerospace Agency) thesaurus (281)
Agriculture:	computer oriented classification (Calaby et al. 79)
Astronomy:	Observatoire de Paris thesaurus (Berardini 45)
Cancer:	Wolff-Terroine (389)
Chemistry:	Atanasiu (18)
Economic development:	computer oriented classification (Calaby et al. 79)
Education:	Croghan (101)
Engineering:	computer-oriented classification (Calaby et al. 79)
Geology:	Michigan University (Briggs et al. 69) and CREDIF (Centre de recherche et d'étude pour la diffusion du français) (Descamps 110)
High-energy physics:	DESY (Deutsches elektronisches Synchrotron) (111) and Euratom (Toma 369)
Information science:	Observatoire de Paris thesaurus (Berardini 45) and Gilchrist et al. (162)
Management:	a French thesaurus (Deweze 112) and a Russian one (Drozdov et al. 121)
Nuclear physics:	INIS (q.v. Section 3.3.1.) by Brzicky (73) and Poletylo (298, 299)
Oil:	Moupeau (278) and Gorokhov et al. (166, 167, 168)
Patents:	Hoffmann (194) and Buhtz (75)
Textiles:	Cumberbirch et al. (102)

A bibliography on thesauri with supplements is compiled by Laureilhe (245).

7.4. Computer construction of thesauri

The technique of thesaurus construction by the machine has been employed mainly for experimental purposes so far. Examples have been described by Alber (7), Armitage et al. (10, 11), Doliatovskii (116) who used a program

written in Cobol, Hines et al. (191), Kato et al. (217), Karasev (216), Kerimov et al. (225) and Janoes (210).

A method using superimposed coding from natural text with trimming algorithms was described by Barinova et al. (35), Chernaya et al. (89), Chernyavskii et al. (90, 91), Files et al. (140) and Hoyle (197). The effectiveness of combining title words with index terms was studied by Fisher et al. (141).

7.5. Testing of thesauri

Various methods have been developed to test and evaluate the efficiency of thesauri. A general survey on indexing methods and their evaluation was made by Bloomfield (56). More specifically the effiency of index terms based on a free text was studied by Barker et al. (36). The syntactic coherence and contextual interference criteria were applied by Rush et al. (318) while the character string length aspect was treated by Smith (347) and Clare (94). Syntactic ambiguities were discussed by Earl (124) and the role of associative memories by Gryaznov (174). The syntagmatic solution of subject headings was investigated by Vlasak (376) and Gupta (176).

A test conducted by Buhtz (75) on a keyword list for the German Patent Office showed that a structured term list was preferable. An experimental framework for observing the indexing process was described by Clarke et al. (95).

8. REVIEWS

Since a considerable number of references found during the compilation of this report dealt with general reviews or surveys of the field of indexing including automatic indexing or were general surveys of automatic indexing, it was decided to list those separately in chronological order so as to give thereby an indication of their up-to-dateness.

1968: Bagley (32)

1969: Azgaldov (31)

1970: Artandi (13), Bely et al. (43), Biseau (53), Carroll (85) with special reference to tape services, Coblans (96, 97), d'Olier (117), Earl (123), East (125), Hashimoto et al. (180), Hines et al. (191), Karasev (215), Lancaster et al. (243), Parker (290), Pigott (296), Sitarska (338).

1971: Bernhardt (41), Berzon (48), Dataflow Systems Inc. (105), Gray et al. (173), Collison (98), Forget (145) including a bibliography, Lannon (244), Lazarescu (248), Lynch (260), Moldoveanu (272), Seki (335), Spranger (354), Wall (377).

1972: Blom (55), Campey (83) including a bibliography of 231 references, Freeman (154), Janos (210), Messinger et al. (267), Wellisch (379).

9. ECONOMIC ASPECTS

Little specific information on the cost effectiveness or other economic criteria of the various aspects of automatic indexing techniques has been found since such activities appear too difficult to permit separation from the wider range of information processing. The principal attempt at isolating the indexing costs was made by Frome (155) in his paper on amortization. Lancaster followed up his work on the testing and evaluation of information retrieval systems (1968, Wiley) in a paper on natural language retrieval systems (241) and Schulz also discussed the cost effectiveness aspects as a guide to developing indexing rules in which reference is made to automatic indexing (330). King et al. (230) used the recall/relevance ratio as a criterion of cost-effectiveness while Tell (363) used the retrieval efficiency criterion to study the Euratom and INSPEC services. Kabi was unable to separate the indexing costs in his analysis of the use, efficiency and costs of external information services (213) of which Schützsack studied the IFIS (International Food Information Service) in detail(331).

The costs of producing KWIC/KWOC indexes in human and machine processes were measured and compared by Campey (82).

The economics of computerized processing in thesaurus construction and maintenance were studied by Hammond (179).

The time savings due to automatic indexing in editing and typesetting were described by Doebler (115).

An analysis of on-line searching costs by Robertson et al. (308) was also unable to isolate the indexing component in a study of the SCISEARCH system.

In the more restricted field of chemical documentation a paper by Park et al. (289) developed a model for estimating computer search time for "CA Condensates".

10. CONCLUSIONS

It is indeed a far from easy task to summarize findings which were disclosed on almost 400 different contributions. Even the few trends which have been detected in some Sections are unlikely to have more than a restricted validity, e.g. the wider use of natural language, or the noticeable increase in special systems etc.

It may therefore be appropriate to repeat the caveat which appeared at the end of the second edition of this survey:
"If machines have not yet mastered us, neither have we yet the requirements of the machine to the degree of advanced planning that will be required, especially for those information processing operations involving the analysis of content and not merely the manipulation of records: for here we are faced with the great challenge of human communication, human decision-making, and human-problem-solving".

The steady progress in the discipline of automatic indexing which has been very noticeable since these words were first written, will probably continue and will thus necessitate a further updating of this state-of-the-art survey. Perhaps the next edition will be able to show more clearly some trends of development and the solution of some of the problems outlined here. It is equally certain that several of those solutions will pose further questions to be answered.

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